

THE DISTRIBUTION OF IO'S THERMAL OUTPUT FROM GALILEO NIMS W.D. Smythe¹, R. Lopes-Gautier¹, L. Kamp¹, L.A. Soderblom², A.G. Davies¹, R.W. Carlson¹, and the Galileo NIMS Team. ¹ Jet Propulsion Laboratory/Caltech, 4800 Oak Grove Drive, Pasadena, CA 91109 (wsmythe@issac.jpl.nasa.gov). ² U.S. Geological Survey, Flagstaff, Arizona 86001.

The NIMS instrument on Galileo has detected numerous hotspots during the Galileo prime mission and the Galileo Europa mission. Most of the hotspots detected by NIMS exhibit single color-temperatures in the range of 350 to 1000 K, temperatures that are above the NIMS minimum detectable temperature of about 180K for filled pixels. Combined data from NIMS, SSI, and ground-based observations have shown that at least 29 hot spots are persistent over periods of one year or more. Persistent hotspots and active plumes are concentrated towards latitudes lower than 30 degrees. Determination of the heat flow from hotspots, and the relative contribution of persistent hotspots, permits assessment of whether persistent hotspots represent a significant fraction of the total heat flow, and are therefore relevant to understanding heat transport below the surface. Though NIMS cannot measure all of Io's heat flow (over half of which occurs at temperatures below 180K), the pattern of power output measured at all hotspots (which contribute about one third of the total heat flow) should represent the distribution of total heat flow at the surface.

The power output of hotspots varies temporally and spatially. Power output maps from NIMS data allows us to assess whether the greatest power output measured in the NIMS wavelength range correlates spatially with the location of persistent hotspots and plumes. Observations of Io in darkness taken by NIMS were used to make the thermal output maps. These thermal maps accentuate hot spots that are difficult to detect by other means. The results so far cover the longitude range 40W to 260W. In this range the hotspots that have the highest thermal output are Amirani/Maui, Altjirra, and Pele/Pillan. The highest thermal output occurs at latitudes lower than 60, which is consistent with the deposition of tidal energy above the mantle.

Io Thermal Output Distribution Maps from Galileo's Near Infrared Mapping Spectrometer

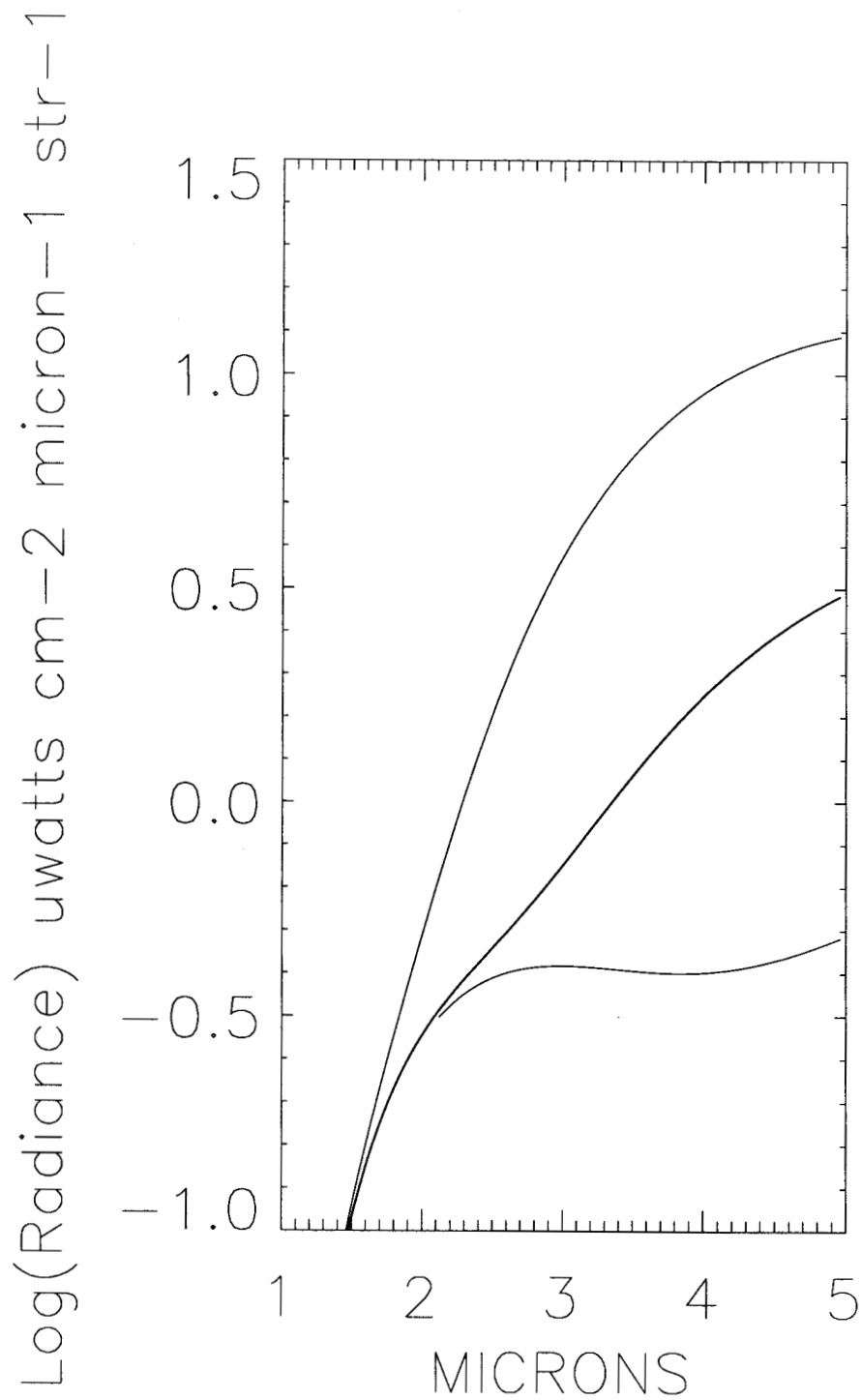
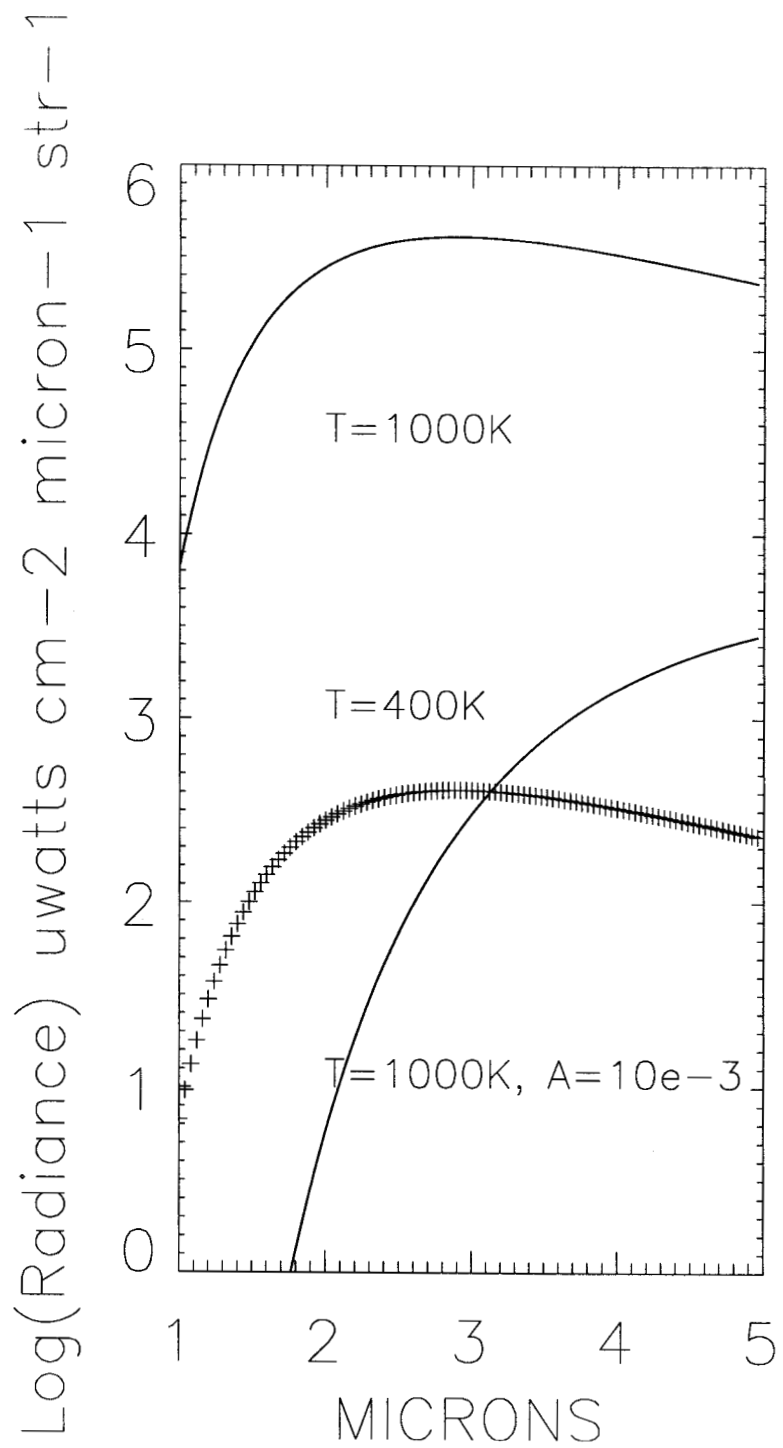
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& the Galileo NIMS team

Io is

- Hot ✓
 - Cold ✓
 - Warm ✓
 - All of the above ✓
- Hotspots are defined as local maxima
 - Cold is below the NIMS detection limit
 - The mean temperature of the largest areas dominates the measurements.

Calculation of power output

- Determine the color temperature for by fitting a Planck function (using least squares with a single temperature and a scale factor as independent variables)
- Determine area from scale factor and resolution
- Estimate the total power radiated at each pixel as $W=A\sigma T^4$



Notes (I)

- The area subtended by pixel is not isothermal. Two-temperature fits can reduce the apparent mean temperature by about 20-50 degrees
- The current model assumes unit emissivity
- Hotspots of very small area not detected
- Areas cooler than 180K are not detected

Galileo-NIMS

Thermal Characteristics

- Wavelength range 0.7 to 5.2 μ
- Dynamic range ~ 1000 , autogain beyond 4.4 μ gives range of about 40000
- Minimum detectable temperature (fully filled pixel) $\sim 180\text{K}$
- Saturation temperature (fully filled pixel) $\sim 600\text{K}$

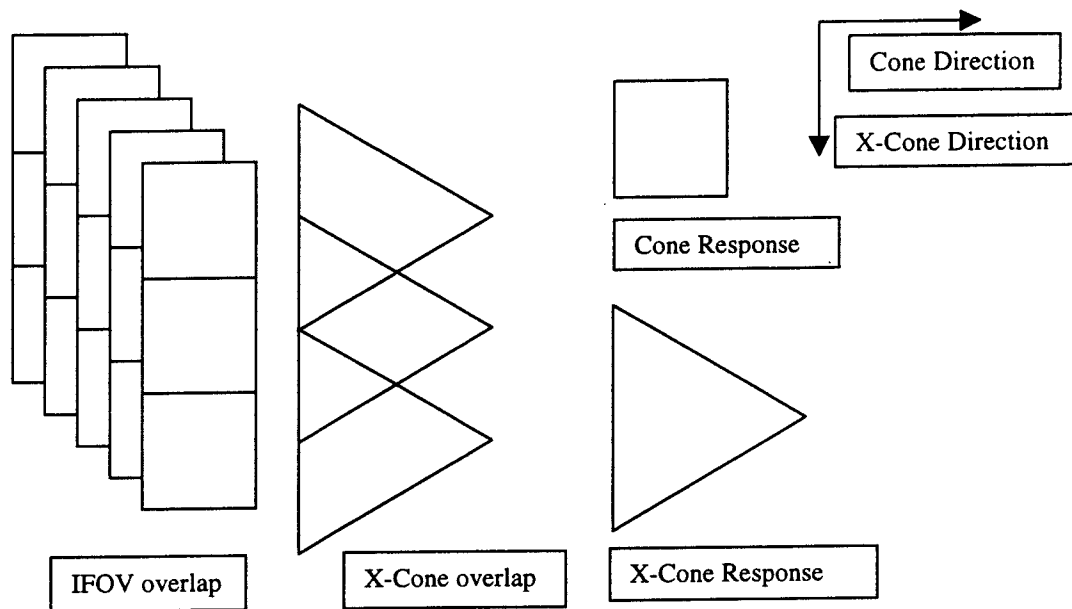
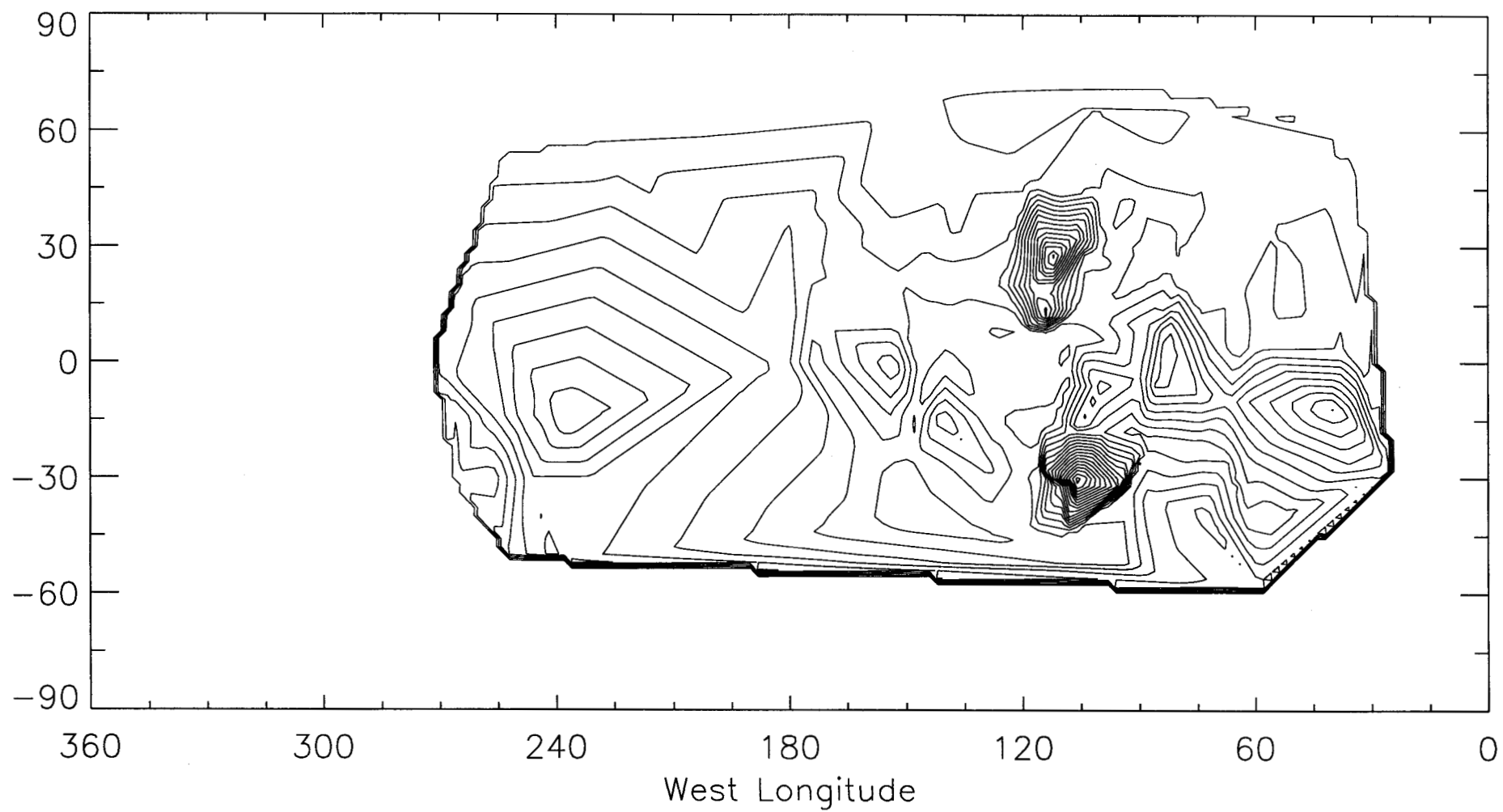


Figure 2: Schematic of operation and shape of the point spread function for the NIMS instrument. The left hand illustration represents the field-of-view overlap for 3 of 20 pixels for a moving scan platform. The horizontal offset is usually $1/50$ of a pixel for each grating step. For Io observations, there is little or no vertical offset. The horizontal motion uses the scan platform actuator and is known as "cone" motion. The motion perpendicular to this (in the field of view) is known as "cross-cone" motion. The right hand figure shows the response for a NIMS field of view. The cone response is nearly square, the response in the x-cone direction is triangular. The middle figure represents the overlap of the response in the cross-cone direction. The response is tapered and extends $1/2$ field of view in each direction. The instrument acquires 20 fields of view in the cross cone direction for each of 24 grating steps.

Notes (II)

- The areas of hotspots are inversely related to temperature. As a result, maps of temperature, area, and power for a given area can have very different relative amplitudes.
- A significant amount of power is emitted from areas with temperatures below the detection limits of NIMS.

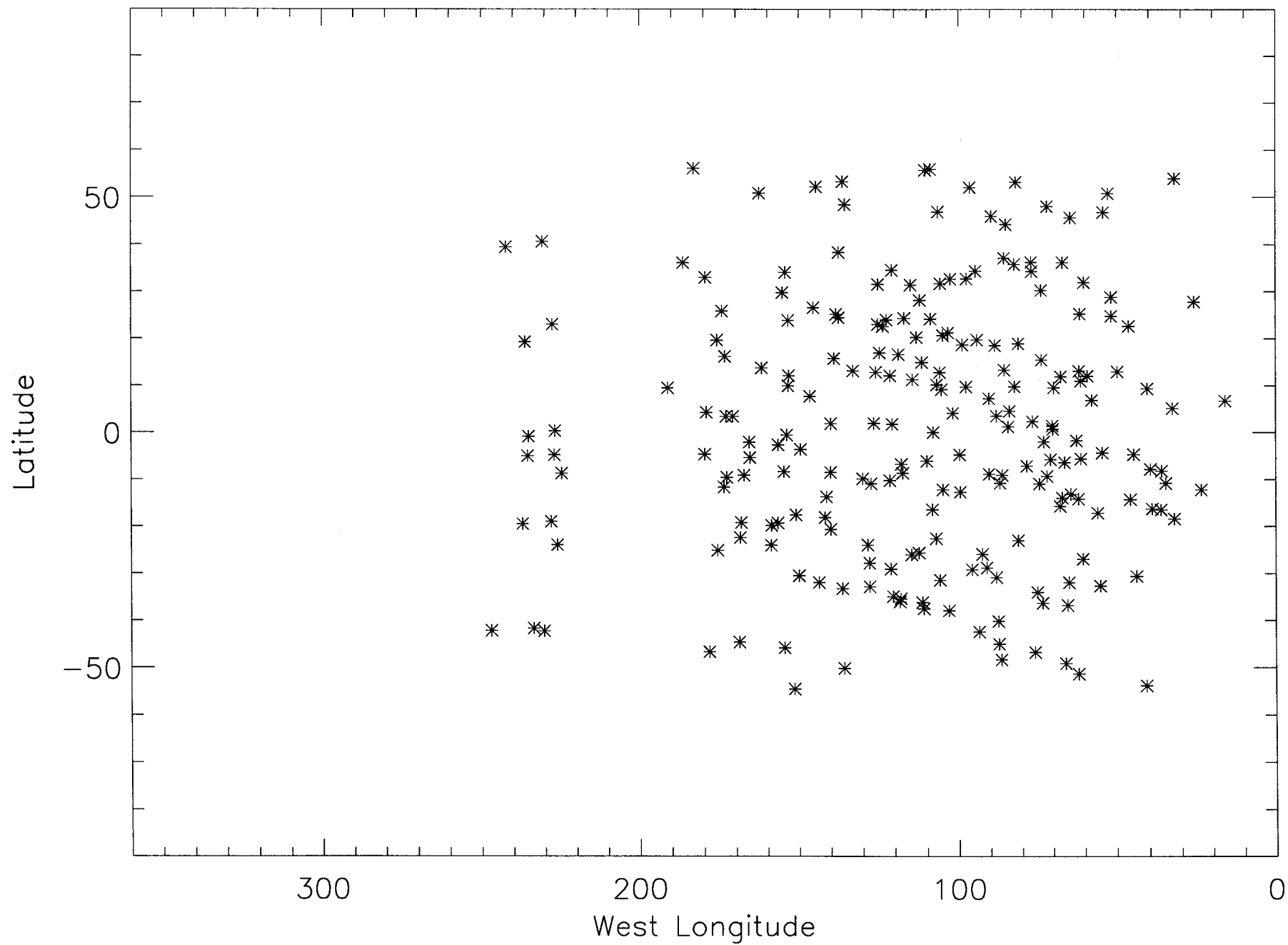
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Observations of Io

- About 100 NIMS observations of Io during the Galileo prime mission
- Resolution ranged from 160 to 320 km/pix
- The majority of these observations have dayside areas
- The data used for these maps are from nightside observations

DISTRIBUTION OF WARM PIXELS



Application

- Constraints on heat deposition models
- Discrimination of (very adjacent) hotspots
- Temporal variability of global output
- Temporal variability and classification of regional output